Understanding Bidirectional Charging Technology and Opportunities

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Those of us who have been working in the world of electric vehicle chargers for years have always followed with great interest the acronym V2G. The reason is simple: If we have batteries with wheels, why would we not use them when and where we need them?

We really must thank our Japanese friends who by the year 2010 founded CHAdeMO (colloquially "*O cha demo ikaga desuka*" which means," Do we have a tea?" as that was the time considered necessary to charge an electric vehicle). At that time Toyota, Nissan, Mitsubishi, Fuji and Tepco started a project to allow the fast charging of electric vehicles and discharging in emergency situations, the so-called V2L (Vehicle to Load).

Many Japanese and European manufacturers have adopted bidirectional charging in smart grids and for buildings or emergency situations under the CHAdeMO standard. Perhaps this is a limitation of this technology since CHAdeMO has been restricted to a few vehicles, especially Asian, while others have embraced the CCS standard based on ISO15118-2 (initially DIN70121) that did not include bidirectional charging in earlier versions.

In June of this year, the turning point for this technology has arrived. The new ISO15118-20 already includes bidirectional charging, and manufacturers are starting to work to incorporate into their vehicles and chargers not only fast DC charging but allowing controlled discharging of the same batteries. OEMs such as Volkswagen, BMW, Ford, Kia, and Hyundai already manufacture vehicles with DC bidirectional charging with the other OEMs expected to follow. On the other hand, the majority of manufacturers of chargers are also incorporating bidirectional chargers, especially "wall box" versions for residences or offices for vehicle fleets.

But it is not just a matter of charging in DC, for some time ago there have been manufacturers that take advantage of the unreserved states of charging in AC to work bidirectional charging directly in AC. One of the pioneers was Renault with prototypes of the Renault Zoe although it never reached the market, currently one of the benchmarks is the Sono with its bidirectional AC charging. This type of charging is much cheaper since the charger can be a simple Wallbox AC, although it is not standardized, does not have common protocols and does not have much support from vehicle manufacturers has not been extended (they must adapt their onboard charger to allow it).

We'll see in the future who will be the winner, for the moment in collaboration with the car manufacturers the DC position may be made stronger.

Let's review the types of bidirectional technology: V2G, V2H or V2L.

V2G

Vehicle to Grid

Vehicle to Grid is based on using the battery of the electric vehicle to supplement an existing electrical network. Using this technology, the utility can balance power peaks or perform aggregation.

With V2G we can complement the power or energy in events, battery charging at cheap(er) rates, and discharging of these batteries at peak rates, etc.

As mentioned, we should treat electric vehicles as batteries with wheels that are distributed throughout the city and potentially available to balance the grid.

V2H

Vehicle to Home

Vehicle to Home, this term can be confusing because many people think V2H is the generation of the electric network necessary to power a building or similar. Others instead understand V2H is similar to V2G, but powers buildings that are already powered by an electric network and therefore do not need the grid.

The most logical explanation is that V2G is intended for more “industrial” or grid-oriented tasks and V2H is more “residential” in scope and intended for small buildings.

V2L

Vehicle to Load

Vehicle to Load means the equipment itself (the vehicle) is used to power small loads generating the necessary electrical network itself. Bidirectional chargers used in case of emergencies to power small appliances or isolated buildings without connection to the grid are examples. Motorhomes, campsites or second homes without connection to the grid also are V2L. Anti-islanding is a concern with this application.

In recent months, KIA EV6 or Hyundai IONIQ 5 vehicles have been introduced to the market allowing small appliances to be powered by V2L.

Regarding the applications there are countless of them where bidirectional technology can be applied. In all of them, software is required via specific protocols to control the charging or discharging of the battery. Without this software it will not make sense to discharge the battery because if we discharge a battery and there is no load to use it, the power will be excess to requirements and wasted.

Accumulation in the Valley and Spending in the Tip

The typical case of using a bidirectional charger is the most beneficial in photovoltaic generation with connected battery storage. If we are able to power the vehicles at cheaper rates or use the car battery to store excess energy from a photovoltaic installation, this energy can be used at times when energy is more expensive.

In case of fleets of commercial vehicles, many of them remain in the parking lots during the day waiting to go out on the street after being all night charging. These vehicles, with software that can control the departure time which allows to ensure the load at a given time, during breaks it can be used to power the office buildings as required.

Use by the Utility to Perform Aggregation

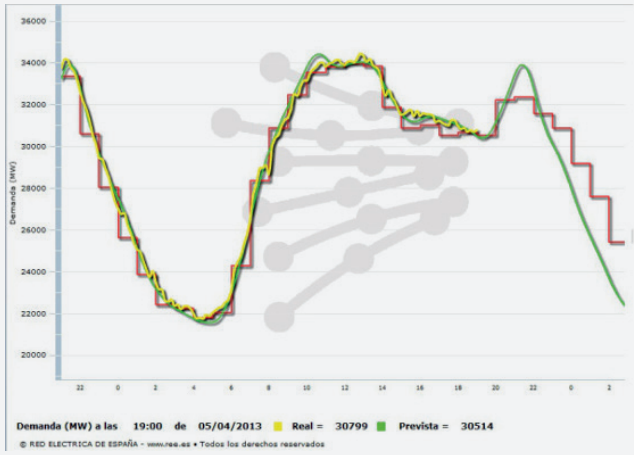
There is also the possibility of selling the use of a battery to a third party. In this case, the user of the vehicle will receive compensation for the availability of the vehicle by the electric company. For example, many European countries have regulations for aggregation that require the regulation of frequency during certain times. In countries such as the UK or Denmark, these times have been drastically reduced to favor a higher network quality.

Currently there are pilots in several countries where they are billing for this availability of fleet vehicles to perform aggregation tasks. The benefit for the company that manages the fleet is significant because the batteries of the vehicles do not suffer when charging or discharging little power and a revenue is generated during vehicle downtime in garages.

The chargers allow the maximum discharge of 10 kW of power and allow the frequency regulations response times of few seconds. The discharge times are typically a few minutes. The battery is always kept between 75 and 80% SOC to maintain its health.

Use By the Utility to Supply Power Peaks

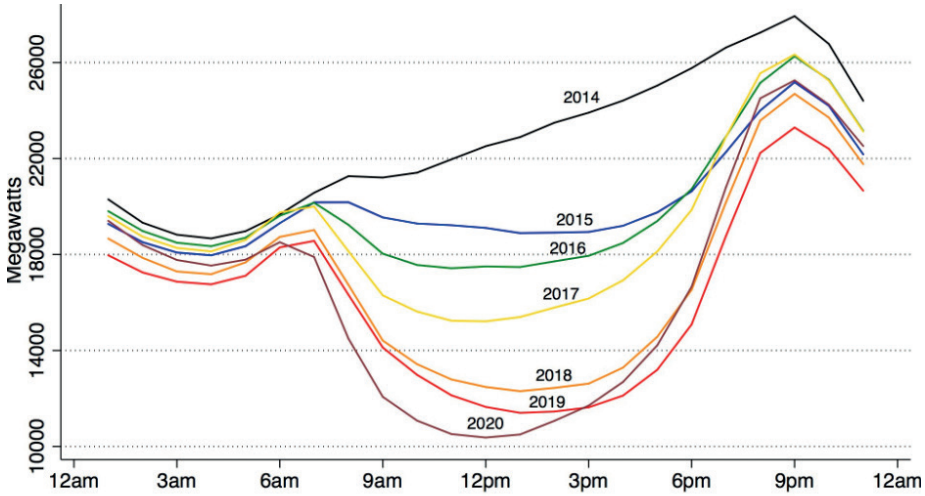
As in the previous case, there is the possibility that the electricity company wants to use the connected vehicles to meet the peak demand. These demand peaks are shown in the following graph.



In this case, as in most European countries, there is a very high demand during the day and lesser at night. The valley of the curve will soften as more electric vehicles charge at night. Most of the vehicles travel during the day to the workplace and/or stay connected to the network without any use. It is during this time the owners will have contracts with the electric companies to provide some of the energy stored in their batteries to meet specific grid peak power demands.

DUCK CURCE ON A TYPICAL SPRING DAY

CAISO AVERAGE MAY NED LOAD BY HOUR



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In the state of California, the curve is different due to high levels of solar and wind generation. This scenario is what many countries will experience with excessive generation during the day leading to cheaper prices during the day than at night. In this case, many vehicles will be storing energy generated during daylight for consumption at night and can also be fast regulators of frequency or power.

Other Solutions

Use for events or power of other vehicles

Having electric vehicles compatible with two-way charging is a guarantee of success in holding events. We can use them as generators so as not to purchase too much power from the grid during peak usage or to provide protection from power failures.

Another interesting application is using a fleet of vehicles to balance state of charge by moving power to vehicles with less energy stored from other vehicles with the battery already full to lower the cost of charging the overall fleet.

There are many applications for bidirectional chargers with the increasing integration within energy storage or photovoltaic applications meaning that many people who did not see it as a real technology can begin to consider its use.

In the case of JABIL, we have deep experience with power electronics projects in both ESS and PV environments. We are always willing to apply the knowledge we have acquired, and we continue to invest in reference designs optimizing the development of new products and technologies.

For example, the development of a proof of concept for a bidirectional DC/DC module based on GaN has led to the study of novel architectures such as Dual Active Bridge (DAB), LCC, etc. well as gaining expertise with GaN power components. We are planning future projects to apply these architectures and new SiC components and new bidirectional AC / DC modules. GaN at some point will overtake the SiC technology in terms of value and cost. It is already considered a high-performance technology for lower power applications. Jabil can apply the know how to SiC and support our customers for faster time to market. Jabil's unique experience and capability helps support design efforts and supply chain fine-tuned for high volume industrialization.

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